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UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

TREATMENT AND SALE OF BLACK SANDS

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BY

M. W. VON BERNEWITZ

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INFORMATION CIRCULAR

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

THE TREATMENT AND SALE OF BLACK SANDS[1]

By M. W. von Bernewitz[2]

Fay's glossary[3] of terms contains the following definition of "black sand":

> Heavy grains of various minerals which have a dark color and are usually found accompanying gold in alluvial deposits, for example, magnetite, chromite, ilmenite, cassiterite, tourmaline, and others.

The Bureau of Mines is issuing this report in answer to the many inquiries from individuals and firms as to how they may treat or sell the heavy black sands that accumulate in the sluice boxes of beach and river placering and to warn such individuals and firms against becoming too enthusiastic over the chances of striking it rich. For a half century or longer much money, energy, and time have been wasted in devising, building, and trying numerous machines to recover gold and platinum, also gem stones, from sand that generally has not been worth the effort. Volumes have been written on the subject, and thousands of letters of inquiry have been received by agencies of the State and Federal Governments. The demand for information has been so great that all of the Bureau's publications dealing wholly or partly with black sands are out of print. They are listed at the end of this report.

Acknowledgment is made to the firms that handle precious metals and to the smelting companies that accept black sands, also to the California State mineralogist, for information supplied.

ORIGIN AND OCCURRENCE OF BLACK SANDS

Following are excerpts from recent publications which give space to black sands:

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7000."

[2] Assistant mining and metallurgical engineer, Metallurgical Division, Bureau of Mines.

[3] Fay, Albert H., A Glossary of the Mining and Mineral Industry: Bull. 95, Bureau of Mines, 1920, 754 pp.

Leaver (General Occurrence)

Leaver's[4] views as to the occurrence and treatment of auriferous black sands are as follows (like other investigators he warns against the few pay spots, failures, and cost):

All black-sand beach deposits vary somewhat in appearance, but heavy minerals are the best indication in prospecting for gold. The highest gold and platinum contents are generally found on the landward side of the deposit where the wave action has been greatest.

The gold and platinum particles usually occur in fine, thin scales which are difficult to recover. They are not easily wetted and therefore tend to float. If the material is dry, it is important for gravity concentration that some form of mixer precede the tabling to assure wetting of the gold and platinum. Concentration by pan, table, or other mechanical device gives better results if performed in water with the least surface agitation or movement.

Even in the better streaks the low value of black sand demands a roughing concentration of the gold and platinum before final recovery methods are applied. These roughing methods comprise treatment on a series of coco **matting**, burlap, or rag runways, various forms of hydraulic classifiers, and mechanical concentrating tables. If the precious metals are concentrated in a small bulk a high percentage of them is easily recovered. The sand is then ready for amalgamation, cyanidation, or smelting.

The byproduct black sands obtained from inland placering are generally of much better grade than beach sands and may warrant treatment by barrel amalgamation and reconcentration of the barrel tailings.

Another possible source of gold associated with black sand is the sand that fills the river beds, particularly in California. Extensive sampling of Feather River sands indicates an average gold value of 11 cents per ton. Simple screening and hydraulic classification have effected a concentration of 200 to 1. The black-sand concentrate thus obtained contains a high percentage of the total gold in the original sand. This gold is readily recovered from the concentrate by cyanidation.

The Snake River in Idaho is well known for its auriferous black sand, the best of which occurs above the river bed and in sand bars projecting into the river. The most actively exploited section is near American Falls. Most of the gold is extremely fine and is difficult to save.

The rich beach sands at Nome, Alaska, have been worked over several times by hand methods. A severe storm destroyed a known pay streak. Beach sands on the west coast of the South Island of New Zealand are being worked profitably at present. The recovery is about 20 cents per cubic yard.

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[4] Leaver, Edmund S., Auriferous Black Sands of the Pacific Coast: Rept. of Investigations 3275, Bureau of Mines, 1935, pp. 51-54.

The platinum, iron, chromium, titanium, and other minerals in the black sands have not proved of marketable value. Even as byproducts they cannot compete with other known deposits.

Jackson and Knaebel (Association of Minerals)

Jackson and Knaebel[5] state that placer gold nearly always is associated with black sands. These sands are composed largely of grains of magnetite (magnetic iron oxide) but may contain various proportions of hematite (nonmagnetic iron oxide), ilmenite (iron-titanium oxide), marcasite and pyrite (sulphides of iron), monazite (cerium, lanthanum, thorium phosphate), rutile (titanium oxide), scheelite (calcium tungstate), tourmaline (boron and aluminum silicate), wolframite (iron-manganese tungstate), zircon (zirconium silicate), chromite (iron oxide and chromium oxide), and other heavy minerals.

During the transportation of placer-forming débris, the grains of quartz and other light minerals are carried away, while the gold, black sands, and associated heavy minerals are dropped and sift down between the boulders and larger pebbles, aided by the sorting action of water, until they rest on bedrock or an impervious stratum of hardpan. Likewise, in panning or other artificial methods of separating and recovering the gold, the black sands and heavier minerals will remain longest with the gold and are the last to be separated therefrom.

Boericke (Relation of Sands and Gold)

Boericke[6] refers to black sand as follows:

> The presence of much black sand may or may not be a good indication of gold. It is usually present in amounts averaging 35 pounds per yard of gravel, but it may be much more. Excessive black sand tends to choke the riffles and makes recovery of fine gold difficult.
>
> An excessive amount of black sand in the gravel shows that conditions were favorable for deposition of gold as well, but it does not follow, unfortunately, that gold will necessarily be found associated with it.
>
> In amount, black sands will vary from 10 pounds to more than 70 pounds per yard of gravel.
>
> If black sands are in any amount, it may be worthwhile to have them assayed for gold content, and if sufficiently high,

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[5] Jackson, Chas. F., and Knaebel, John B., Small-Scale Placer-Mining Methods: Inf. Circ. 6611, Bureau of Mines, 1934, p. 4.

[6] Boericke, W. F., Prospecting and Operating Small Gold Placers: 2d ed., John Wiley & Sons, New York, 1936, pp. 16, 23, 33, 28-29, 44-45, 84-86, 92-93.

they can be sold to smelters. Of course, there is little use in collecting a few hundred pounds of them, unless other operators can be persuaded to make up a joint shipment.

Along Clear Creek, Colo., the ground yields 5 to 6 pounds of black sand per cubic yard.

Savage (Sand as an Indicator of Gold)

Savage[7], in the chapter on placer mining, states:

> Black sand and ruby sand, because of their high specific gravity and comparative abundance and because of the fact that they are affected by the same conditions that control the concentration of gold, become good indicators of the possible presence of gold. Black sand is a form of iron oxide. It is very magnetic. Ruby sand derives its name from its reddish color and is in reality composed of garnets. If these minerals are disseminated through the deposit, it is not likely that a concentration of gold will be found. If, however, they are found concentrated in distinct horizons, then it is very likely that gold, if it is present, will be found concentrated also.

Horner (Pacific Coast Deposits)

The following notes are taken from Horner's[8] well-known report of 1918, when fine gold sold at $20.67 an ounce and platinum at $106 an ounce:

For more than 60 years the black sands of the Pacific coast have been exploited for their gold content, and at an early date platinum and its associated metals were known to exist in some of the placers of northern California and southern Oregon. In the early days, however, the platinum, which occurs in fine, thin scales, was given little attention because of its low value and limited market. It was even considered objectionable and was usually discarded as worthless when the gold clean-up was made. Many of the old clean-up dumps have since been worked for their platinum content, some with gratifying results.

The ancient beaches, 1 to 5 miles inland, did not prove so rich or so easy to work as the present beaches.

Black-sand mining in the past has been a fruitful field for unscrupulous promoters and has been especially alluring to men who had little knowledge of mining. These swindlers usually claim that they have some wonderful machine or process for extracting gold and platinum from the sands.

7/ Savage, Eros M., Prospecting for Gold and Silver: 1st ed., McGraw-Hill Book Co., New York, 1934, p. 9.

8/ Horner, R. R., Notes on the Black Sand Deposits of Southern Oregon and Northern California: Tech. Paper 196, Bureau of Mines, 1918, 42 pp.

The black sands are the hard and more-resistant minerals left after erosion of the iron-magnesium rocks and comprise particles of quartz, olivine, garnet, zircon, and other silicates; magnetite, chromite, ilmenite, and hematite; and frequently a little gold and platinum. Small quantities of these particles are found in nearly all water-borne sands and gravels.

The chief trouble with the black sands is their meager content of gold and platinum. A few small, isolated areas are fairly rich through local concentration, but most deposits of the material contain only a few cents worth of gold and platinum per ton.

Samples taken carefully by Horner contained from zero to 0.06 ounce of gold and platinum per ton, but most of them contained from zero to 0.01 ounce.

He concludes his report thus:

> The results of the investigation may be summarized by the statement that in general the black-sand deposits are disappointing in both value and quantity; they rarely contain enough gold and platinum or occur in adequate quantity to be exploited at a profit.
>
> On the other hand, black-sand concentrates saved in hydraulic mining, dredging, and other forms of placer operations may have a value up to several thousand dollars per ton. These two classes of material [beach black sands and black sands from sluicing and dredges] should not be confused when discussing black sand.
>
> Experience has shown that in many cases error has been made [in working] because the gold content of a particular sample or deposit was not known. Fire assays of representative samples by competent assayers give accurate results and should be considered final in determining the gold content. * * * The maximum value that may be expected in moderate quantity will not exceed 40 to 60 cents per ton. A few individuals have been able to make a living by working exceptionally high-grade spots by hand methods, and a few operators have reported success working on a somewhat larger scale, on material which ran 25 cents per yard. All attempts, however, to work these sands in California on a large scale have thus far invariably ended in failure. The impression has been given out that these failures have occurred because the gold and platinum are supposed to exist in some peculiar form and that it cannot be recovered by any known means. This idea is not borne out by facts. * * *
>
> The gold and platinum, when present, are usually found in very fine flakes and scales, and much of the gold in the old beach deposits is "rusty" or tarnished. This makes it somewhat difficult to save in the sluice box or to amalgamate.

There are, it is true, a few favored places where small areas of the black sand show some precious-metal content, and these may become the site of small operations.

The chief difficulties in the profitable exploitation of these deposits are: First, lack of uniformity in occurrence and metallic content; and, second, the high cost of mining and treating the materials.

Laizure (Californian Deposits)

Black sands from California contain the following minerals, according to a report[9] of the State Division of Mines.

Analysis of Californian black sands

Mineral	Specific gravity	Pounds per ton of sand
Magnetite	5.17	50 to 1,100
Chromite	4.1 to 4.9	10 to 125
Ilmenite	4.5 to 5.0	200 to 600
Garnet	3.1 to 4.3	1 to 80
Quartz	2.6	200 to 1,000
Zircon	4.7	15 to 25
Unclassified	Within above range	100 to 200

Crude gold has a specific gravity of 15 to 19 and crude platinum, of 14 to 19.

The following statement as to their value is pertinent:

> It may be safely said that the natural concentrations of black sand in beach deposits are very low grade - much lower than is usually admitted by those who would exploit them.

CLEAN-UP

When the sluice boxes have been cleaned out and the free gold, amalgam, and heavy sands collected, the next step is to recover for retorting all of the precious metals possible.

Washing

By repeated panning, rocking, tabling, use of a magnet, and passing the sands over cloth of some kind, most of the more or less worthless material may be discarded and the high-grade concentrate made available for special treatment. Figures 1, 2, and 3 show the pan, rocker, and long tom; figure 4 shows details of riffles; and figure 5 shows a horseshoe magnet and a bar magnet.

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[9] Laizure, C. McK., Elementary Placer Mining in California: Calif. Jour. Mines and Geol., State Division of Mines, vol. 30, April and July, 1934, pp. 121-251.

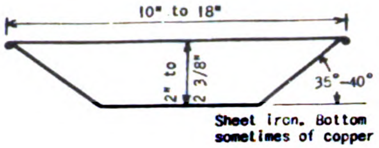

Figure 1.- Gold pan.

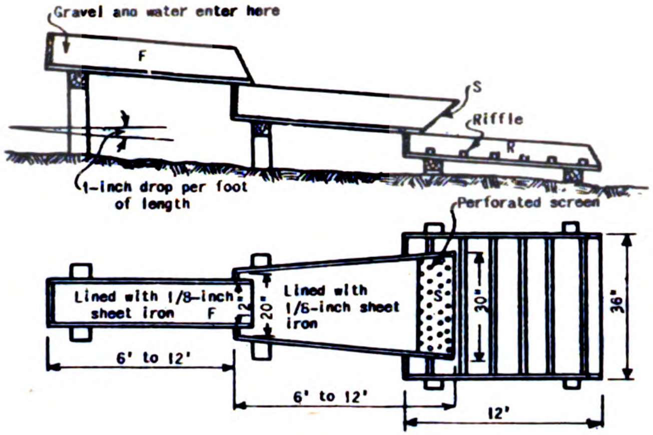
Gravel and water enter here
F
S
Riffle
R
1-inch drop per foot of length
Perforated screen
Lined with 1/8-inch sheet iron
F
12"
20"
Lined with 1/8-inch sheet iron
S
30"
36"
6' to 12'
6' to 12'
12'

Figure 3.- Long tom.

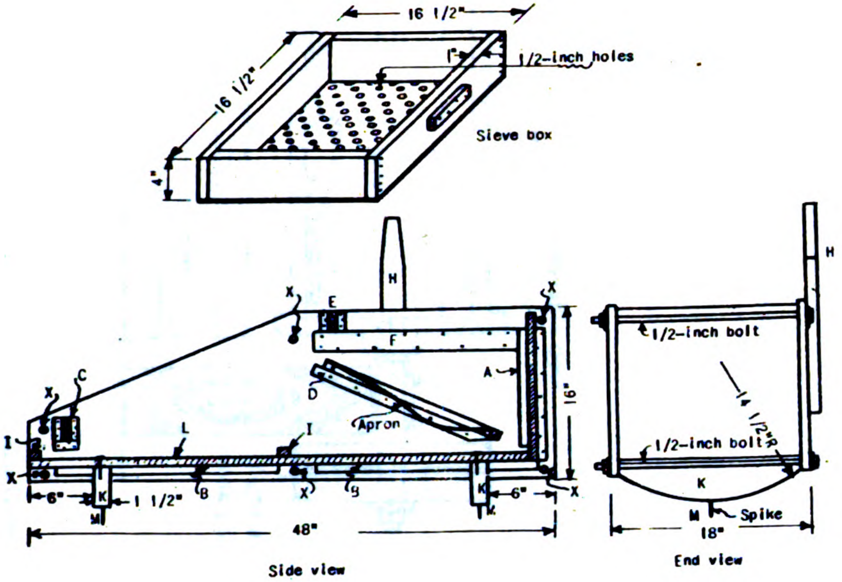

Figure 2.- Sketch of knock-down rocker and view of sieve box (from Eng. and Min. Jour.).

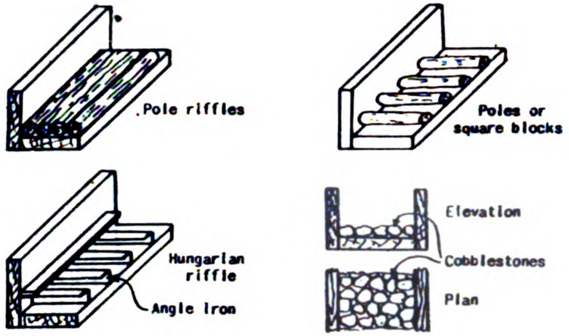

Figure 4.- Common types of riffles.

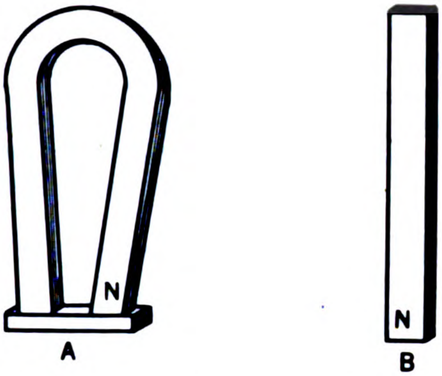

Figure 5.- A, Horseshoe magnet; B, bar magnet.

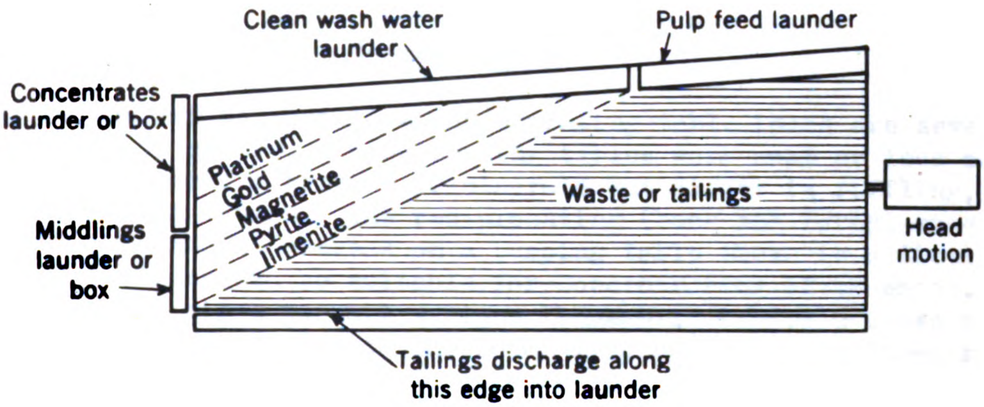

Figure 6.- Top of a gravity table, showing approximate strata of minerals.

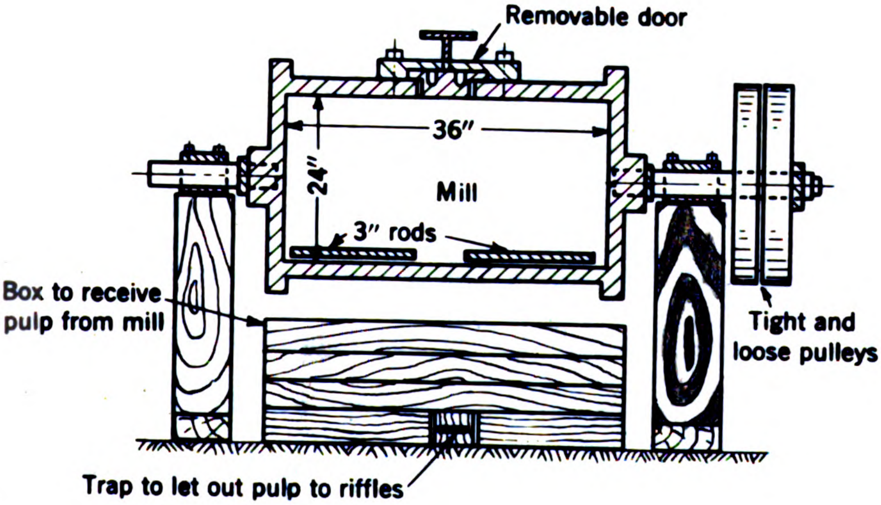
Removable door
36″
24″
Mill
3″ rods
Box to receive pulp from mill
Tight and loose pulleys
Trap to let out pulp to riffles

Figure 7.- A ball-mill suitable for grinding and amalgamating rich sands.

The common pan is of steel and is 6, 12, and 16 inches in diameter. As a rule they are obtainable from hardware stores in mining centers. If not, firms such as the Braun Corporation, Los Angeles, and Braun-Knecht-Heiman Co., San Francisco, Calif.; Denver Equipment Co., Denver Fire Clay Co., and The Mine & Smelter Supply Co., Denver, Colo.; and Eimer & Amend, New York City, sell these sizes of pans at 40 cents, 40 to 65 cents, and 70 cents to $1 each, plus transportation charge.

These firms also sell magnets; the 6-inch size costs around 40 cents.

Rockers and long toms can be built on the job from the dimensions given.

Because the gold particles may be more or less coated with iron, the magnet may attract some of them with the real iron minerals, and some gold may be lost. Therefore, the iron minerals should be carefully examined before they are discarded.

Concentrating

If it is desired to install a concentrating table there are several makes from which to choose. These shaking tables work more or less on the principle of the specific gravity of minerals but differ in riffling, tilt of the top, and head motion. The reciprocating (back-and-forth) movement is continuous and smooth, whereas on a bumping table there is a distinct stop. A sand table should be suitable for concentrating black sands. They are made in several sizes to suit various tonnages. Figure 6 shows the top of one table. It is covered with one-color linoleum, and the lines represent wooden riffles which are tacked on and taper from 1/4 inch in height at the feed end to a knife-edge at the other end. This table has a stroke of 3/4 inch and is run at 240 strokes per minute. The set or tilt of the top toward the discharge is adjustable and is altered to suit the class of material being fed. This machine will handle up to 20 tons a day. It is made right-handed or left-handed to suit any flow sheet.

The following shaking tables, otherwise known as concentrators or gravity tables, can be obtained from the firms listed:

Butchart - Butchart Manufacturing Co., Joplin, Mo.

Card - C. S. Card Iron Works, Denver, Colo.

Deister-Overstrom - Deister Concentrator Co., Fort Wayne, Ind.

James - James Ore Concentrator Co., Newark, N. J.

Overstrom-Universal - Straub Manufacturing Co., Oakland, Calif.

Plat-O - Deister Machine Co., Fort Wayne, Ind.

Wilfley - The Mine & Smelter Supply Co., Denver, Colo.; Salt Lake City, Utah; El Paso, Tex.; and New York City.

Reconditioned tables of several makes can be obtained from the following firms:

Morse Bros. Machinery Co., Denver, Colo.

Western Machinery Co., Sacramento, Calif.; San Francisco, Calif.; Los Angeles, Calif.; Denver, Colo.; Phoenix, Ariz.; and Salt Lake City, Utah.

Grinding

Grinding and amalgamation is the most practical and satisfactory method of treating black sands. Grinding the rich, coarse sand brightens the gold and makes it more amalgamable. The barrel or the berdan may be used for this purpose; both are simple machines, and recovery of gold by either is virtually complete. The grinding pan is also suitable.

Amalgamation Barrel. - Laboratory ball mills and the smaller ball mills used in regular ore grinding could be adapted to grinding black sands, but several firms make amalgamation barrels. These are not lined, but are of 2-inch cast iron and last a long time. Figure 7 shows a suitable barrel.

Two types of barrels are available; one is a complete casting with steel trunnions cast in an enlarged center at each end; the other is a cast cylinder with ends made separately and bolted on and trunnions attached. In both types one trunnion is extended for fast and loose pulleys. The barrel may be revolved in either direction. As a rule, there is one charging or clean-out door at the center, made tight by means of a clamp having a rubber gasket. Some barrels have two holes, either directly opposite at the center or opposite at each end. One hole is sufficient. A barrel 24 inches in diameter runs at 15 to 30 revolutions per minute. The Denver Equipment Co. makes several sizes, but the 24- by 36-inch size has a capacity of 300 to 400 pounds per charge and uses 3 horsepower. It can be set on two concrete piers or on a wood frame. Beneath it should be a tight box to receive the ground pulp and mercury, a small slide door at one side, and riffles to catch the rich material.

Operation of an amalgamation barrel is briefly as follows: It is charged with concentrate and enough water to make a fairly thick pulp when ground. (Don't overcharge.) Enough mercury is added to collect the gold. A few pounds of lime or a little lye will aid amalgamation. For grinding, two or three short lengths (say, 12 inches) of 2- or 3-inch rod or shafting are better than balls. The hand hole or door is closed tight and the barrel run all day or overnight. To clean up, stop the barrel with the door up, unscrew the cover, and allow the pulp to drop into the box below. Wash out the barrel and remove the grinding rods. Carefully wash the pulp from the box through the little door to the riffles, and wash these free of all sand. Then scoop out the mercury. Pieces of iron and steel should be picked out, and the tailings may be run over corduroy to a special dam and eventually dried and sold, if valuable, a fact determined by assay.

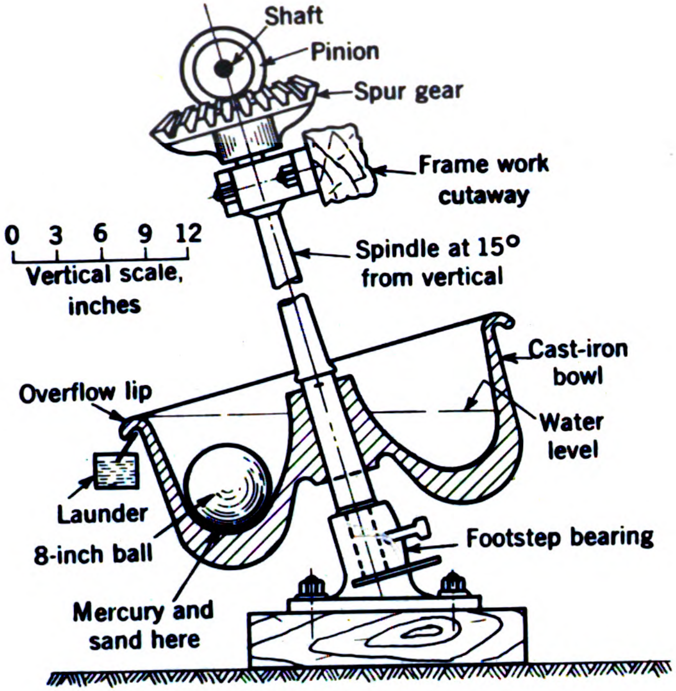

Figure 8.- Vertical section of Berdan pan; supporting frame removed. (After Henry Louis, with notations by present writer.) Some Berdans are gear-driven beneath the pan, this eliminating the spindle and top gear.

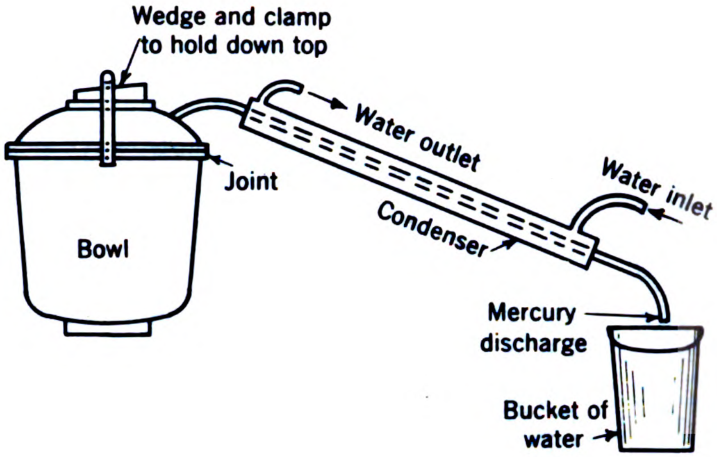

Figure 9.- A retort for amalgam or mercury containing gold. This represents one of 1/2-gallon and holds 50 pounds of mercury; the retort weighs 25 pounds.

The foregoing was the practice of the compiler of this report; every step is simple, and the results are satisfactory.

Following is a list of makers and suppliers of ball mills that may be suitable for clean-up purposes. All of them make or have stocks of machines that may be adapted to such use, but those starred (*) cater to the small operators as well as to large ones.

*Paul O. Abbe', Ind., Little Falls, N. J.

Allis-Chalmers Mfg. Co., Milwaukee, Wis.

American Ball Mill Co., Denver, Colo.

*Denver Equipment Co., Denver, Colo.

Eimco Corporation, Salt Lake City, Utah

W. W. Gibson, Alameda, Calif.

Hardinge Co., York, Pa.

Hendrie & Bolthoff Mfg. & Supply Co., Denver, Colo.

*Joshua Hendy Iron Works, Sunnyvale, Calif.

Kennedy-Van Saun Mfg. & Eng. Corporation, Danville, Pa.

*Mine & Smelter Supply Co., Denver, Colo.

Morse Bros. Machinery Co., Denver, Colo.

*Straub Mfg. Co., Oakland, Calif.

Traylor Eng. & Mfg. Co., Allentown, Pa.

Western Machinery Co., Sacramento, San Francisco, and Los Angeles, Calif; Phoenix, Ariz.; Salt Lake City, Utah; and Denver, Colo.

Berdan Pan. - The berdan pan is a simple, old-time machine for cleaning up or grinding rich concentrates, but it is staging a come-back. The compiler of this report has used it and thinks highly of its work. It may be run in charges or with continuous feeding and overflow, depending on the material being treated. When used in the former manner, the feed is added, and, when ground fine enough, water is turned on and the slime is washed out. This procedure is followed until the lot to be treated is finished. In continuous operation the amount of water added determines the fineness of grinding. Some milling plants run berdans day and night grinding concentrates. Figure 8 shows a Berdan pan.

The original berdan may be described as a cast-iron basin 4 feet in diameter with a central cone through which is run a steel spindle. The bottom end of the spindle projects about 12 inches and fits into a footstep bearing and the top end projects about 4 feet with spur gear at the end and a guide bearing below it. A wooden frame is built, and the bearings are placed so that the pan and spindle are at an angle of 15° with the vertical. The spur wheel is driven by a pinion on a horizontal shafting fitted with tight and loose pulleys. The pan may be driven either right or left. It may have a close-fitting cast-iron liner. Grinding is done by one large (100 pounds or more) or two small loose balls or, better, by a heavy drag cast to shape and held part way up one side of the pan by means of a chain. The pan's direction of travel is down from the drag, but either direction is suitable if balls are used. The speed is 20 to 30 revolutions per minute - just fast enough to carry around the material to be ground. A quantity of mercury which is determined by experience is placed in the bowl of the pan. The water and ground pulp overlow at the lowest point of the pan's lip onto a sloping table which fits closely under it and thence into a launder to waste or to be dammed for possible further treatment when enough accumulates. Such a berdan will grind 1 or 2 tons of concentrates a day.

To clean up after the last charge has been ground and washed out of the pan, the surplus water is dipped out, the balls are lifted out (the drag may be left in), and the mercury and amalgam are scooped up for retorting. As in all machines that have liners, some gold and amalgam will get behind that in a berdan, but eventually this will be recovered when relining it.

Two machinery manufacturers in the West make different types of berdans. That of the Joshua Hendy Iron Works consists of an underframe of 6- by 6-inch lumber at the top of which are a step bearing and a guide bearing, into which fit the spindle of a cast-iron bowl and the drive shafting, which has tight and loose pulleys. The bowl, about 30 inches in diameter, has no central cone, and no spindle rises out of it. The pan is set at an angle and is gear-driven below. This is a handy clean-up pan.

The Mine & Smelter Supply Co.'s berdan is suspended within a frame of angle iron and channel iron. The bearings are bolted to the latter. A horizontal shafting, with tight and loose pulleys and pinion, drives (in a box) the spur which is attached to the spindle rising from the central cone of the bowl. There is no footstep bearing. The bowl is 24 inches in diameter and is driven at 20 revolutions; at this speed it uses less than 1 horsepower. An 8-inch steel ball is the grinding medium.

Wheeler Grinding Pan. - A clean-up pan of the Wheeler type is made in Denver. It is designed for batch or continuous grinding and amalgamation of high-grade ore and concentrates. By its use, free metallics can be removed before concentrate is sent to a smelter, or the material being ground may be treated at the mine. A brief description of this pan follows: The pan, which sits on a low wood frame, is of 1-inch cast iron. In the center is cast a hollow tube through which passes a steel spindle that engages a yoke

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and grinding muller in the pan and is gear-driven beneath. The muller has shoes attached and these grind on dies at the bottom of the pan. In operation, the batch or flow of pulp is run into the pan, mercury is added, and the muller lowered onto the dies while the pan is rotating, this being done by means of hand-wheels and a screw spindle working in the yoke. The slime produced overflows from a weir which is cast onto the pan's side. The amalgam accumulates between the dies and where their lugs engage the side of the pan and the central spindle tube. Operation and clean-up are simple, the writer of this paper having run a group of eight 60-inch pans on rich ore.

This pan is made in 4 sizes - - 12, 24, 36, and 60 inches diameter. The 24-inch size is suitable for small plants. It is built up of welded plate and the muller spindle is gear-driven from the top. This size requires 3 horsepower and weighs 1/2 ton.

Amalgamating Drum. - Another machine suitable for treating small quantities of black sands or clean-up material is the Denver amalgamating drum. The 12-inch size has a capacity of 25 to 50 pounds per charge and sits on the same foundation as a 3/4-horsepower gasoline engine or electric motor. The drum is belt-driven. Ordinarily, a single large ball grinds and amalgamates the pulp. A tilting device allows the slime to be drained out while the machine is rotating. The concentrate is removed through a drain outlet on the amalgam groove. This collects the mercury and holds the concentrate while the slime is being discharged.

Machines Made at the Mine. - The laboratory investigations of the Testing and Research Laboratories of the Mines Branch, Department of Mines, Canada, during 1932 included the recovery of gold from black-sand concentrate from a placer in British Columbia. A barrel-amalgamation test saved almost 100 percent of the gold in the sand, which assayed 3.92 ounces per ton. How to adapt a grinding machine to the job is described as follows:

> A home-made barrel can be constructed from an empty gasoline drum [55-gallon capacity] placed on rolls which can be driven by a 3-hp. gasoline engine or a small water wheel.
>
> A small barrel for the individual miner can be made from a 5-gallon oil drum or wooden wine cask; paddles can be attached to the cask; and by fixing trunnions to each end, it can be made to revolve by the current of the water in the sluice box.
>
> Another way the individual miner can amalgamate his black sand is to purchase a small grinding muller used in an assay office for grinding small samples of rock, or he can buy a cast-iron mortar and pestle and grind the black sand with mercury and water.
>
> In each case he would pan his amalgamated sand to recover the mercury.

Two hints concerning the use of gasoline and oil drums may be added:

1. Be sure that no open light is brought to the openings because of the possibility of igniting gas.

2. Be sure that the drum is thoroughly cleansed of oil to prevent possible fouling of the mercury.

Handling Amalgam

Mercury that has picked up gold on copper plates, sluices, barrel, or pan should first be cleansed of sand, iron, and other material. This is done by skimming off these materials in the riffles or in a mercury bucket and adding more mercury to make the whole liquid. The clean metal may be retorted, or it may be squeezed through any close-woven cloth and the ball of amalgam which remains retorted.

If pipe and tools are available on a claim, a home-made retort and condenser may be built. Otherwise, it is better to buy one from one of the supply houses listed in this circular. Retorts of 1-pint to 1-gallon water capacity - there are several sizes - cost from $4 to $9 each. (See fig. 9.)

A furnace using any type of fuel may be made of brick or rock, or a forge may be used. The retort should stand on a brick, and the fuel should entirely surround it. Before the amalgam is placed in the retort the inside of the bowl should be washed with a clay or lime emulsion or lined with paper. The lid should be clamped tight, using a clay joint. Heat the retort gently at first, and later give it plenty of heat.

The curved pipe from the retort top may be cooled and the mercury vapor condensed by means of wetted sacks or by a regular condenser surrounding the pipe through which cold water circulates. The condensed mercury runs into a bucket of water. When it stops, retorting is finished. The fire by this time has been allowed to burn down.

The hot retort is lifted out of the fire and the top removed. (At this time a little mercury vapor will rise from the bowl, so stand aside.) The retorted gold is taken out and sold locally or sent, insured and with instructions, to the San Francisco, Denver, or Philadelphia Mints.

Review of Current Methods

The following excerpts on the handling of black sands are taken from several reports on placering:

Alaskan Practice

During 1920 the Bureau of Mines made a series of tests on four large samples of black sands at its experiment station in Fairbanks, Alaska. The findings were published[10] the same year and may be tabulated as follows:

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[10] Davis, John A., and Gross, John, Recovery of Gold from a Magnetic Black Sand: Rept. of Investigations 2158, Bureau of Mines, 1920, 5 pp.
Davis, John A., and Gross, John, Recovery of Gold from Black Sand by Classifier Concentration: Rept. of Investigations 2160, Bureau of Mines, 1920, 3 pp.
Gross, John, Recovery of Gold from Black Sand Tailings: Rept. of Investigations 2170, Bureau of Mines, 1920, 2 pp.
Gross, John, Comparison of Gold Recovery from Black Sand: Rept. of Investigations 2192, Bureau of Mines, 1920, 4 pp.

Tests on Alaskan black sands

Item	Lot			
	1	2	3	4
Weight, pounds	112	770	210	536
Source of material	Sluices	Sluices	Classifier	Sluices
Condition as received	Mercury added and some gold amalgamated at mine.	Treated by amalgamation at mine; assayed 11 cents a pound.	From amalgamated concentrate at mine.	Treated by amalgamation at mine.
Composition	90 percent magnetite and garnet.	Mainly schist and quartz; little ilmenite and garnet.	Fine gold encased in quartz; 12 percent as metallics.	Mainly rutile, quartz, pyrite, and schist; some garnet, scheelite, and magnetite.
Screening done	Plus 10-mesh material discarded as free of gold.	Plus 4-mesh material discarded as free of gold.	Plus 28-mesh material hand-jigged; undersize run over canvas.	All minus 4-mesh material.
Tests made	Magnetic separation, amalgamation, and cyanidation; table and classifier concentration.	Classifier concentration to 17 percent of original bulk and amalgamation.	Gold recoverable by grinding and amalgamating jig concentrate; canvas concentrate re-treated on canvas and in grinding barrel.	Classification, concentration, and amalgamation of concentrate; concentration without classification and amalgamation; concentration in classifier and on canvas, and amalgamation; ground and amalgamated.
Recovery of gold, percent	89 to 97	81	- - - -	89 to 99+
Recommendations	Treat in amalgamating barrel after reducing bulk in classifier.	Screen out coarse material that is free of gold, classify fine sand, and amalgamate concentrate	Hand-jig coarse sand and run fine sand over canvas; grind and amalgamate.	Concentrate and barrel-amalgamate with some grinding with plenty of water and mercury.

The foregoing summary of carefully run tests shows that it is best to discard coarse sand that is free of visible gold, then to concentrate the remainder in a classifier or jig (see fig. 10, reproduced from Taggart's Handbook of Ore Dressing), and finally to amalgamate first and second concentrates and grind them in a barrel of some type.

F. D. deVaney and W. H. Coghill, of the Bureau of Mines, describe jigs as follows:

The feed may be sized or unsized. The jig sieve may be movable or fixed. If movable, the sieve constitutes the bottom of a frame or basket which works in a tank of standing water. The simplest jig is a hand jig whose feed and discharge are intermittent. It is useful at a small mine. Jigs with fixed sieves are more common and generally are home-made. The motion of the water is actuated by a plunger, either at the side of the jig cell or under it. New water must be added to replace what passes over the tailboard and through the hutch. When much water is used fine material rides on the charge, and when little water is added a suction is created that draws fines into the hutch.

The quantity of black sand produced by each operator in Alaska is small. Treatment for recovery of any gold not obtained by classifier and canvas-table concentration, followed by barrel amalgamation of the resultant concentrates, would be profitable only when handling large quantities of black sand.

Classifier concentration followed by barrel amalgamation of the concentrate and finer part of the tailing is recommended where the amount of black sand produced is so large or its value so low that amalgamation of the entire amount of black sand is not practicable. A classifier plant of this type can be built and operated easily and cheaply where water is plentiful.

Wimmler[11] under the heading "Cleaning heavy sands" states that at some Alaska mines all the heavy sands are panned, rocked, or put over special sluices. Some fine rusty or coated gold or amalgam ordinarily remains in the sands. It is customary to stir the sands in a tub or vat with cyanide or to put them in a clean-up barrel, add cyanide, lye, or wood ashes, rotate the barrel to brighten the gold, and amalgamate the gold in the barrel. This treatment takes 20 minutes to several hours, after which the sands are panned or passed over special riffles or mercury-coated plates of copper. Even then the sands may contain gold.

Boericke (Magneting and Rocking)

Boericke[12] states:

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[11] Wimmler, Norman L., Placer-Mining Methods and Costs in Alaska: Bull. 259, Bureau of Mines, 1927, p. 216.

[12] Boericke, W. F., See footnote 6.

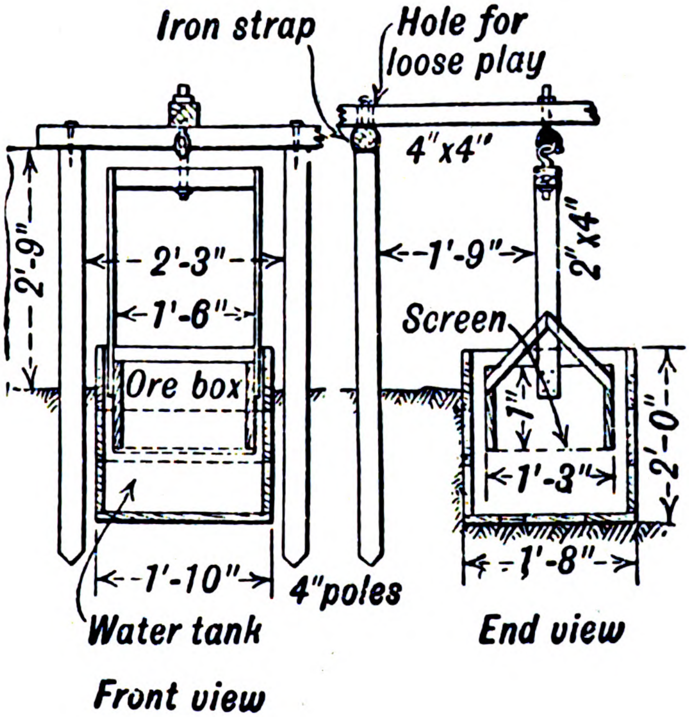

Figure 10.- Simple hand jig (after Taggart).

When a fair quantity of black sand and gold particles has been accumulated, and the material has become thoroughly dry, the larger colors can be picked up with sharp-pointed tweezers, and most of the black sands - all that are magnetic - can be removed with a horseshoe magnet. In using the magnet, it is a good plan to wrap some cellophane around the ends; then, when the magnet is withdrawn, the sands will drop off without sticking to it. Such nonmagnetic sands as still remain can often be removed by using a blow box. This is made from a sheet of heavy tin, about 8 inches long, 6 inches wide on one end, and 5 inches on the other. The edges are turned up about 1 inch on three sides, leaving one side open, and the corners soldered together. Put the sands and gold dust in the box, hold it level, and blow lightly across it, tapping the box at the same time. With some practice, a surprisingly clean separation can be made, the lighter sands being blown out and the gold dust remaining behind.

The riffles [in a rocker] are cleaned up when it is thought necessary; not so often as the apron. Three or four times a shift should be sufficient. With the hopper clear of gravel, clean water is run into the machine for a few minutes while it is being rocked, so that all of the light sands and some of the concentrated material in the lower riffles are removed. The black sands and fine gold are brushed out from the riffles into a pan for further separation. If a blanket or corduroy has been used, it is carefully taken up and rinsed in a tub of water to recover the gold.

The riffles as well as the interstices of the coco matting should be watched to see that they do not pack with black sand, as this would permit the fine gold to slip over the top and escape. If black sands are present in quantity, increase the slope of the rocker. The proper grade is the least slope that will keep the black sands thoroughly agitated. The grade will vary with the rapidity of feeding, the amount of clay, and the fineness of the gold. Fine gold needs less slope than coarse gold, provided that there is no packing of black sands. If there is trouble with the clay binding the gravel, the slope cannot be less than 2 inches; however, building the rocker larger will give a better chance for the fine gold to settle.

Laizure (Sluices and Platinum Recovery)

To aid in the recovery of fine gold in the sluice box, it is customary to line the bottom with various materials, such as coco matting, brussels carpet, blanket, burlap, canvas, corduroy, moss, cowhide with the hair on, sponge rubber, or other similar materials, held down by cleats or wire netting. * * *

> Satisfactory amalgamation of the rusty gold usually can be accomplished by grinding the material to scour and brighten it, so it will be taken up on contact with mercury. Such gold will also amalgamate readily in the presence of a solution of cyanide. * * *
>
> Separation of the platinum from the black sand is more readily made if the concentrate after amalgamation of the gold is screened and the different screen sizes are treated as separate lots, or the whole ground to a uniform size. The material should be dried, then, by blowing and careful use of a magnet, a very clean platinum concentrate can be obtained. Patience and careful hand work are required.[13]

Clean-up methods of some dredging companies are detailed by Laizure. The long tom is in general use. Some of the platinum is recovered with the main lot of amalgam, but most of it is in the black-sand concentrate which also contains amalgam, rusty gold, scrap iron, and lead. This material is reduced to small volume, usually in the long tom. The base metals are separated and saved, as they contain some amalgamated gold. The platinum is recovered by panning the final long-tom concentrate several times. Its separation from the small amount of gold is easy because it will not amalgamate without special treatment (such as treatment with sodium amalgam), but panning is slow and must be carefully done. The black sand frequently receives no further treatment but is stored for possible future attention.

Raeburn and Milner (Identifying Minerals in Black Sands)

Raeburn and Milner[14] believe that the complete separation and identification of the "black minerals" is one of the most difficult tasks confronting the prospector. They recommend the use of the pan, magnet, and lens and observation of the crystal forms. A list gives 11 black minerals ranging in specific gravity from 3.1 for tourmaline to 9.5 for thorianite, which is rare, and in hardness from 5.5 for ilmenite to 7.5 for tourmaline.

Ross and Gardner (Clean-up in Wyoming)

Following is the clean-up practice[15] of the E. T. Fisher Co. on Rock Creek, South Pass district, Wyoming, at an elevation of 7,600 feet. The gravel, which is easy to dig and free-washing, contains about a teaspoonful of sand to the pan. A small part of the gold is rusty and does not readily amalgamate. About 2,800 cubic yards are dug daily by a dragline shovel.

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[13] Laizure, C. K., See footnote 9.

[14] Raeburn, C., and Milner, Henry B., Alluvial Prospecting: Thomas Murby & Co., London, 1927, pp. 201-202.

[15] Ross, Charles L., and Gardner, E. D., Placer-Mining Methods of the E. T. Fisher Co., Atlantic City, Wyo.: Inf. Circ. 6846, Bureau of Mines, 1935, 10 pp.

Good News Bay, Alaska

During the summer of 1937 Olsen's camp on Squirrel Creek, 10 miles from Platinum, Good News Bay, Alaska, was visited by a newspaper man, Ernie Pyle, whose observations were printed in The Washington (D. C.) Daily News for August 23, 1937. At Olsen's claims on Platinum Creek 25 men were working, and a dragline and dredge were under construction. Two 10-hour shifts are worked. Pyle stated that he and the superintendent examined the black sand behind the riffles in the sluice box but could not see any platinum, although actually there was plenty in the sand. It is finer than gold and is almost the same color as the sand. At clean-up time they run the sands through a rocker and ship the final concentrates in cloth sacks to Tacoma, Wash.

DISPOSAL OF SANDS

The method of recovering gold from black sands on the claim has been described. If it is desired to sell the sand without taking out any gold, it should be concentrated to the least possible bulk. Pan samples may give an idea of the gold and platinum content, but the safest procedure is to send a carefully taken sample to one of the many reliable assayers in the West. If the sands are valuable enough, send them by parcel post or by express to one of the buyers listed.

Buyers of Black Sands and Platinum

Following is a list of buyers of black sands and crude platinum grains, but no shipments should be made without first ascertaining that the minerals are worth shipment and writing for information as to freight or express and treatment charges. The compiler of this report has been told by the larger works that in general they have found the sands to be of low grade.

Black Sands

American Metal Co., Ltd., Carteret, N. J. (United States Metals Refining Co.). (Write to company at 61 Broadway, New York City; platinum payment depends upon assay of sands.)

American Smelting & Refining Co., Selby, Calif.; Tacoma, Wash.; Garfield, Utah; East Helena, Mont.; Leadville, Colo.; Omaha, Nebr.; El Paso, Tex.; Hayden, Ariz. (Write to nearest smelter; platinum not paid for.)

Baker & Co., Ind., Newark, N. J. (If precious metals are in payable quantity and the sands are of suitable amount. Concentration to small bulk advised.)

International Smelting & Refining Co., Tooele, Utah. (No large quantity could be handled; platinum not paid for.)

The concentrate is treated first in a steel sluice with a puddling box at the head to separate out the live mercury. The material is stirred with whisk brooms to cause droplets of mercury to coalesce. Most of the black sand is run to waste. The riffle product from the steel box is treated in two batches in a 2- by 4-foot cylindrical amalgamation barrel that is turned 40 r. p. m. by a 1-1/2- hp. gasoline engine. Enough water to make a thick pulp and about 5 pounds of mercury are added to each batch, which is ground 35 minutes. Old cast-iron bucket teeth are used as grinding media. When there is any indication of grease in the concentrate, a can of lye or a tablespoon of cyanide is placed in the barrel. The material from the clean-up barrel is run through the steel clean-up box again, and the amalgam and live mercury are recovered. The remaining black sands are run to waste. One man requires about 6 hours to treat the concentrate from one clean-up. The live mercury from both clean-up operations is strained through bags of 8-ounce canvas, and is then ready to re-use. The amalgam is squeezed by hand and retorted; the sponge gold is shipped to the mint. About 650 wet ounces of amalgam produces a bar worth $10,000.

Stolfa (Minerals Remaining after Removing Magnetic Portion)

Stolfa[16] recommends the use of the magnet for testing the magnetic qualities of minerals and for separating black sand from gold in a pan. Complete separation is sometimes difficult without a magnet and some mercury. As a rule, the main part of the black sand is worthless, being composed of iron minerals; valuable minerals lag behind in the residue after removal of magnetic portion. Those that have a metallic luster and may remain with the black sand are platinum, palladium, iridosmine, wolframite, and uraninite. Those that do not have a metallic luster but remain in the sand are cassiterite, scheelite, corundum, diamond, and topaz.

Vanderburg (General)

Vanderburg[17] describes the sluice and clean-up at some claims:

> When cleaning up, the riffles are removed and a small stream of water is allowed to flow down the sluice to wash the heavy sand. The nuggets are picked up by hand and the black sand concentrate collected and washed in a gold pan or rocker. The black sands, if magnetic, may be separated from the gold by a magnet after the concentrate has been dried. To prevent fouling of the magnet, a piece of cellophane may be interposed between the magnet and the magnetic material.

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[16] Stolfa, L., Prospecting for Gold: 1932, pp. 21, 101.

[17] Vanderburg, William O., Placer-Mining in Nevada: Univ. of Nevada Bull. 4, vol. 30, May 15, 1936, p. 44.

Johnson Matthey & Co. (Canada), Ltd., 198 Clinton Street, Toronto, Ontario, Canada. (Concentration to small bulk advised. This firm would make assays at $10 for the platinum-group metals and negotiate for the sale of black sands to its parent company in London, England.)

F. L. Newsome, 523 23d Avenue, San Francisco, Calif. (Buys black sands from individuals and dredges and treats them in a new plant near Smartsville, Yuba County.)

Western Gold & Platinum Works, 589 Bryant Street, San Francisco, Calif.

Wildberg Bros. Smelting & Refining Co., 742 Market Street, San Francisco, Calif.

Following is a list of buyers of crude platinum grains:

Platinum

American Platinum Works, 225 New Jersey Railroad Avenue, Newark, N. J.

Baker & Co., Inc., 54 Austin Street, Newark, N. J.

J. Bishop & Co. Platinum Works, Malvern, Pa.

Goldsmith Bros. Smelting & Refining Co., 1300 West 59th Street, Chicago, Ill.

Handy & Harman, 82 Fulton Street, New York City.

Irvington Smelting & Refining Works, Irvington, N. J.

Pacific Platinum Works, Inc., 814 South Spring Street, Los Angeles, Calif.

Platinum Metals Corporation, 261 Fifth Avenue, New York City.

Shreve & Co., Bryant and Zoe Streets, San Francisco, Calif.

Western Gold & Platinum Works, 589 Bryant Street, San Francisco, Calif.

S. S. White Dental Co., Philadelphia, Pa.

Wildberg Bros. Smelting & Refining Co., 742 Market Street, San Francisco, Calif.

Hints to Sellers. - Returns received from the sale of crude platinum are disappointing to miners who are unaware that quotations usually refer not to the price of the metallic content of crude platinum but to that of the pure metals that have been subjected to treatment, which is costly.

Pure platinum does not occur as such. The tin-white malleable grains and flakes that occur in some placers and lag behind the gold in the pan are crude platinum-group metals which contain probably not more than 65 percent of platinum. Therefore, cash transactions are frequently made at a price several dollars - as much as $10 - an ounce less than the market price for platinum, whose average price in 1937 was $52.

The present per-ounce price of the platinum metals (refined) is: Platinum, $34; iridium, $82; palladium, $24; osmium, $47; rhodium, $122; rhuthenium, $37. During 1937 the prices were much higher. The respective rounded average prices during 1936 were $42, $88, $23, $47, $65, and $34.

Iridium has been the most valuable of the platinum metals. It is harder and heavier than platinum, and its grains are sharper and more angular than the softer, purer platinum. The crude platinum product may contain iron, which reduces its selling price.

The actual value of the crude platinum, if all the metals are paid for, depends on the proportion of each in the crude material, less the difficulty and cost of separating and refining them.

During 1936 the output of crude platinum in the United States was 3,174 ounces from Alaska (higher in 1937), 928 ounces from California, 80 ounces from Oregon, and 21 ounces from miscellaneous sources. Most of that from California and Oregon was probably from dredges.

ASSAY OF BLACK SANDS

Hopkins[18] has described the types of black sands and the methods of assaying them. He says:

> No great difficulties will be encountered in assaying black sand from beaches or river bars. Such samples require great care in grinding and sifting so that no oversize particles of gold or platinum are lost. It is also necessary to have enough silica in the flux to form a fluid slag with the excess of iron, magnesium, or chromium which such samples contain.
>
> It is more difficult to assay black sands, or concentrates, produced in large-scale placer-mining operations. These products are usually much harder and more abrasive than the black beach sands. They also contain numerous metallic particles resulting mainly from wear on mining machinery. * * * Fairly large particles of gold are often found. Some samples will contain as much as 10 percent of such metallic particles. * * *

Hopkins continues by describing the methods of preparing the sample for assay and the assay and calculations, but these are not discussed here as this report is not concerned with assays made by small operators.

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[18] Hopkins, Paul, Assay of Black Sands: Rept. of Investigations 3265, Bureau of Mines, 1934, 5 pp.

PUBLICATIONS ON BLACK SANDS

HORNER, R. R. Notes on the Black Sand Deposits of Southern Oregon and Northern California. Tech. Paper 196, Bureau of Mines, 1918, 42 pp.

DAVIS, J. A., and GROSS, JOHN. Recovery of Gold from a Magnetic Black Sand. Rept. of Investigations 2158, Bureau of Mines, 1920, 5 pp.

------- Recovery of Gold from Black Sand by Classified Concentration. Rept. of Investigations 2160, Bureau of Mines, 1920, 3 pp.

GROSS, JOHN. Recovery of Gold from Black Sand Tailings. Rept. of Investigations 2170, Bureau of Mines, 1920, 2 pp.

----- Comparison of Methods of Gold Recovery from Black Sand. Rept. of Investigations 2192, Bureau of Mines, 1920, 4 pp.

HOPKINS, PAUL. Assay of Black Sands. Rept. of Investigations 3265, Bureau of Mines, December 1934, 5 pp.

LEAVER, EDMUND S. Auriferous Black Sands of the Pacific Coast. Rept. of Investigations 3275, Bureau of Mines, June 1935, pp. 51-54.

All these reports are out of print and only available for reading in libraries.